Update on Bone-Anchored Hearing Aids in Pediatric Patients With Profound Unilateral Sensorineural Hearing Loss

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Objective: To evaluate the use of bone-anchored hearing aids (Bahas) in children with single-sided deafness.

Design: Retrospective 3-year chart review.

Setting: Arkansas Children's Hospital, Little Rock, pediatric hospital serving children from birth to 21 years of age.

Patients: The study included 23 children (14 girls and 9 boys) with single-sided deafness (mean age, 12.6 years; age range, 6-19 years).

Interventions: Two-stage Baha surgery with 6-month osseointegration was performed on children 5 years and older at a single institution. The Baha processor was placed 2 weeks after the second-stage surgery.

Main Outcome Measures: Results of the Hearing in Noise Test (HINT) and the Children's Home Inventory for Listening Difficulties (CHILD) questionnaires were compared before and after Baha activation in children with profound unilateral sensorineural hearing loss.

Results: Preimplant mean HINT scores at speech-noise ratios of 0, +5, and +10 dB were 42%, 76%, and 95%, respectively. Postimplant mean HINT scores improved to mean speech-noise ratios of 82%, 97%, and 99% at 0, 5, and 10 dB, respectively. The CHILD scores also improved from mean preimplant ratings of 4.49 and 4.60 for patients and parents, respectively, to postimplant ratings of 6.90 and 7.10. Both teenagers (n=15) and children younger than 13 years (n=7) demonstrated improved HINT and CHILD scores. The complication rate was 17%.

Conclusion: Bone-anchored hearing aids are a durable treatment option that can achieve noticeable improvements in hearing in noise and in listening difficulties in children with profound unilateral sensorineural hearing loss.

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THE INCIDENCE OF PROfound unilateral sensorineural hearing loss (USNHL), otherwise known as single-sided deafness (SSD), in children ranges from 0.1% to 3%.[1,2] Evidence suggests that children with profound USNHL perform poorly in school, display learning difficulties, and have behavioral problems relative to their normal-hearing peers.[3-5] These problems can be attributed to the inability of individuals with SSD to perform well in noise.[6-8] Therefore, special resource assistance, preferential seating, FM amplification, and CROS (contralateral routing of signals) hearing aids are available to improve comprehension and performance in children with SSD. Despite evidence that children with SSD benefit from FM systems and CROS amplification, there is still limited compliance in the use of these devices.[9-11] They especially do not work well outside the classroom. Thus, treatment options for profound UNSNHL in children are limited, thereby creating a source of frustration and a need for alternative treatments.

In an effort to provide a durable treatment option, the bone-anchored hearing aid (Baha) has been explored for use in children with SSD. The Baha is a surgically implantable system that was created to take advantage of the high speed (low impedance) at which sound can travel through bone. It specifically conducts amplified sound directly and immediately to the cochlea from its abutment placed in the parietal bone. Since it was approved by the Food and Drug Administration for patients 5 years and older, the Baha has been effective in treating children and adults with unsalvageable bilateral conductive hearing loss. Adults with SSD have recently demonstrated tremendous benefit from its use.[12,13]

Table. Results by Age

Variable	Preimplantation	Postimplantation
Children <13 y		
HINT, SNR, %		
At 0 dB	34	75
At +5 dB	88	96
At +10 dB	99	100
CHILD score		
Patient	4.93	7.07
Parent or guardian	4.93	7.63
Teenagers		
HINT, SNR, %		
At 0 dB	33	87
At +5 dB	75	97
At +10 dB	94	100
CHILD score		
Patient	3.46	7.20
Parent or guardian	3.47	7.31

Abbreviations: CHILD, Children's Home Inventory for Listening Difficulties; HINT, Hearing in Noise Test; SNR, speech-noise ratio.

The use of the Baha in children with SSD remains controversial, as its benefits have not been fully elucidated. In a pilot study, our department reported significant improvement in hearing in noise and in quality of life in 3 teenagers who were using the Baha for profound USNHL.[14] This improvement was demonstrated through better scores on the Hearing in Noise Test (HINT) and Children's Home Inventory for Listening Difficulties (CHILD) questionnaires, respectively. The goal of the present study was to examine the impact of Bahas on children of various ages with profound USNHL.

METHODS

After institutional review board approval, the medical records of children with profound USNHL were reviewed. As a routine, complete audiologic and otologic examinations (often multiple) were performed before a patient was diagnosed as having SSD. Computed tomographic scans were conducted on each patient to look for cochlear or other temporal bone anomalies, including an enlarged vestibular aqueduct on the ipsilateral or contralateral ear. Once SDD was confirmed, intervention options, including personal FM systems, sound-field systems, preferential classroom seating, CROS hearing aids, and Bahas, were discussed with the patient and the patient's family, without bias.

Parents of children 5 years and older, in accordance with Food and Drug Administration regulations, were offered the Baha as a treatment option for their child's profound USNHL. If parents expressed an interest in the Baha, a trial with the Baha on a test band was provided to the children to evaluate the device's potential benefit. Loaner Baha processors were given to some families if requested. If the patients and their families wished to pursue implantation, the risk and benefits of the surgery were discussed. The 2-stage surgery was outlined, with an expected osteointegration period of at least 6 months for all patients. Computed tomographic scans were reviewed for adequate parietal thickness (3 mm) to accommodate Baha implantation.

All patients received a 2-stage surgery and were fitted with either a Baha Divino or Baha Intenso (Cochlear Bone Anchored Solutions, Gothenberg, Sweden) 2 weeks after the second-stage surgery. The HINTs were performed before and after the Baha fitting, with speech stimuli and noise both at 0° azimuth. Also, each patient and a parent or guardian were asked to complete the CHILD questionnaire before and after the Baha fitting.

RESULTS

A total of 23 pediatric patients (14 girls and 9 boys) were implanted with the Baha system for profound USNHL at our institution over a 3-year period. There were 6 teenagers and 7 children younger than 13 years of age (average age, 12.6 years). All patients in this study underwent 2-stage procedures, with at least 6 months allowed for osteointegration. Failed osseointegration occurred in 1 child, which led to a longer interval between surgical stages. Two teenage patients had skin reactions and underwent a skin revision around the abutment in our clinic. One teenage patient lost a fixture. The total complication rate was 17% (n=4); complications were more common in teenagers.

Preimplant HINT mean scores at the speech-noise ratio (SNR) were 42%, 76%, and 95% at 0, +5, and +10 dB , respectively. Postimplant HINT scores improved to a mean SNR of 82%, 97%, and 99% at 0, +5, and +10 dB, respectively. The CHILD scores also improved from preimplant average ratings of 4.49 and 4.60 for the patients and parents, respectively, to postimplant average ratings of 7.10 and 6.90. Both teenagers (n=16) and children younger than 13 years (n=7) demonstrated improved HINT and CHILD scores, with the greatest benefit seen in the teenage group (**Table**).

COMMENT

The Baha system has been a treatment option for hearing loss over the past 30 years and in more than 30 000 patients worldwide. The procedure for the implant is usually performed on an outpatient basis. Both single- and 2-stage procedures are available depending on the patient age, skull thickness, and surgeon's preference. In the pediatric population, 2-stage surgery is often performed to allow proper time for osseointegration of the Baha abutment, as in this study. The Baha implant does not present a risk of hearing loss or damage to the existing hearing mechanism. The Food and Drug Administration approved the use of the Baha in children 5 years and older in 1996 and for patients with SSD in 2002. Since then, the Baha has been used in adults with SSD, with good outcomes. The result is the sensation of hearing from the deaf ear. Criteria for Baha use in SSD are profound USNHL in the setting of a normal-hearing contralateral ear. To our knowledge, its role in children had not yet been explored.

Adult patients using the Baha have shown increased understanding of speech in noise and increased patient satisfaction. In particular, Hol et al[12] demonstrated a better ability to understand speech in noise and a lifted-head shadow effect in adults using the device. Patient satisfaction was also improved and remained high for at least 1 year after fitting, as determined by the Abbreviated Profile of Hearing Aid Benefit, the Glasgow Hearing Aid Benefit Profile, the International Outcome Inventory for Hearing Aids, and the SSD questionnaire. Lin et al[13] also compared the Baha with the CROS hearing aid in 23 adults. They found that the Baha outperformed the CROS hear-

ing aid as determined by an increase in understanding speech in noise according to improved HINT and Source Azimuth Identification in Noise Test scores.

Based on the above results and our own pilot study in teenagers, our hearing program now routinely offers the Baha as a treatment option for profound USNHL (SSD) in children older than 5 years. The same criteria for Baha placement in adults are applicable to the pediatric population. After a trial period with a Baha processor attached to a Baha test band, many children and their parents have requested permanent implantation of the device. If a Baha is desired, a computed tomographic scan is performed to assess parietal thickness before surgery. Preoperative and postoperative questionnaires have been conducted to assess the value of a Baha after implantation in these children. A retrospective review of the results demonstrated that in 23 children with profound USNHL the Baha system yielded improved child and parent satisfaction (higher postimplant CHILD score) and a better ability to understand speech in noise (HINT scores). Despite the success in hearing and quality of life, it was also important to assess the risk of Baha implantation.

After performing the simplified Nijmegen surgical technique, de Wolf et al[15] reviewed their results with 129 Baha fixtures and found that 21 (16.3%) had been lost or removed. In 12 cases, osseointegration failed. Of the 16.3% of the fixtures that were lost, 86% of the losses occurred within 1 year after surgery. The authors found no difference in the rate of complications between age groups or fixture lengths (3-mm vs 4-mm implants). Nonetheless, they noted that Baha fixtures were "less stable" in children than in adults. This was reflected in 1 child (age, 10 years) in the present study in whom osteointegration initially failed. We find this rate to be remarkably low considering the variable thickness of parietal skull in children undergoing Baha placement. In this study, skin complications were more common and contributed to a total complication rate of 17%, for which revision surgery was required. Although children should likely be monitored more frequently, with longer osteointegration intervals, after Baha placement, the complication rate in children seems no different from that in their adult counterparts.

In conclusion, the treatment of children and teenagers with profound USNHL has been frustrating owing to the known disability associated with this condition and to a lack of acceptance and benefit of traditional amplification techniques. We found a significant improvement in performance in noise using HINT and improved satisfaction using the CHILD questionnaire in children with profound USNHL. These finding are helpful in counseling children 5 years and older and their families regarding treatment options for SSD.

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